

# Maryland Ozonesonde Campaign 2005

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**Overview** The Maryland Department of the Environment (MDE) Air Quality Planning and Monitoring Program designed an ozonesonde measurement campaign for the summer of 2005. The ozonesonde campaign scope of work, schedule, and product design were prepared by the MDE and implemented by the Physics Department at Howard University (HU) at their Beltsville, MD field laboratory site. Under tutelage from NASA-Goddard, HU Physics Department students assembled and launched the ozonesondes/rawinsondes when the MDE air quality forecast was for code orange or red conditions. The main goals of the ozonesonde campaign were three fold: (1) Public Outreach – Educate the general public about ozone transport. (2) Policy – Gain insight into interstate ozone transport to better direct policy decisions towards fair and equitable interstate emission control strategies. (3) Science – Measure the ozone concentrations transported by predominant westerly aloft winds, the Appalachian Lee-Side Trough, and the nocturnal low level jet into the residual layer.

## Ozonesonde Platform

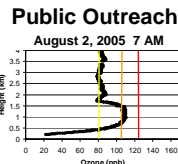


## Launch Summary

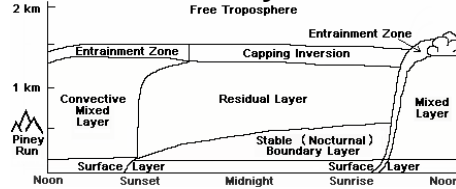
Launch Days	Date in 2005	Launch Time (EDT)		
		Morning 6 AM-Noon	Afternoon Noon-6 PM	Night 6 PM-6 AM
1	Jul 18		3:00 PM	
2	Jul 19	9:00 AM		
3	Jul 21		3:30 PM	
4	Jul 26	9:00 AM	2:00 PM	
5	Jul 27	8:00 AM	2:30 PM	
6	Aug 2	7:00 AM	2:30 PM	
7	Aug 3	7:00 AM		
8	Aug 4	7:00 AM	2:30 PM	
9	Aug 5	7:30 AM	2:00 PM	3:30 AM
10	Aug 12			10:30 PM
11	Aug 13	6:00 AM	2:00 PM	
12	Aug 14	6:00 AM		2:30 AM
13	Aug 17		1:30 PM	
14	Aug 25	6:00 AM		
<b>Total</b>	<b>Jul 18 to Aug 25</b>	<b>10 Launches</b>	<b>9 Launches</b>	<b>3 Launches</b>

## Data Products

Sonde – O<sub>3</sub>, T, RH, WS, WD, P  
MDE Profiler – WS, WD  
UMBC Lidar – Aerosol Scattering  
MDE Surface Monitors – O<sub>3</sub>, T, RH, WS, WD, Trace Gases, PM<sub>2.5</sub>



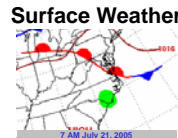
## The Residual Layer (after Stull, 1988)



The nocturnal Residual Layer is a zone of laminar flow where pollutants and precursors are transported via aloft westerly winds and the nocturnal low level jet.

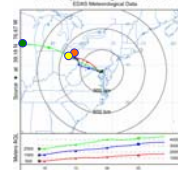
## Local v/s Transported Ozone

The surface map shows a warm front indicating local ozone buildup over Maryland. The peak ozone AQI map that shows code yellow and orange locally verifies this.

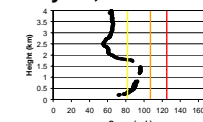


However, the ozone profile and back-trajectories reveal peaking ozone aloft and upwind sources with yellow and orange AQI.

## Back-Trajectories



July 21, 2005 3:30 PM



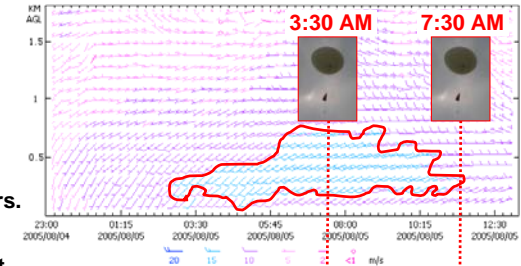
## In-Situ Measurements and Remote Sensing of the Nocturnal Low Level Jet

As a highly anticipated air quality episode, five ozonesondes were launched at Beltsville during the two day period of August 4-5, 2005. The campaign enjoyed great success as the nocturnal low level jet (LLJ) was observed using four independent measurement platforms: two in-situ ozonesondes and two remote sensors.

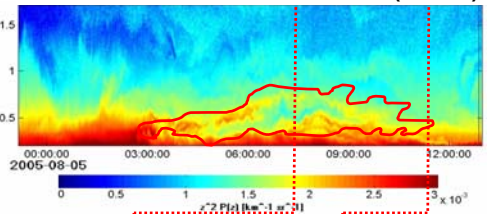
At Beltsville the MDE wind profiler remotely detected the LLJ at a height of 0.2km-0.8km for a period of 8.5 hours. In addition the UMBC LIDAR, located in Catonsville and operated by R. Hoff and R. Rogers, remotely detected a thick residual aerosol layer experiencing enhanced turbulent inhomogeneities and stratification at the same heights and for the same period of time.

Finally, two independent ozonesondes were launched four hours apart in Beltsville and both measured the LLJ in-situ. The 3:30 AM and 7:30 AM launches detected peak LLJ speeds of approximately 14m/s at 0.5km and 11m/s at 0.4km, respectively. In both cases the winds veered from the surface to the core of the LLJ and continued veering through the rest of the LLJ up to 1.3km where the winds were weak at 6m/s and began backing.

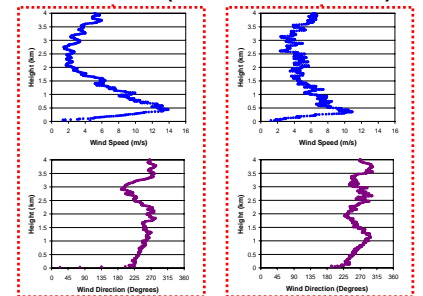
### MDE Beltsville Wind Profiler



### UMBC Catonsville Polar ELF LIDAR (R. Hoff)

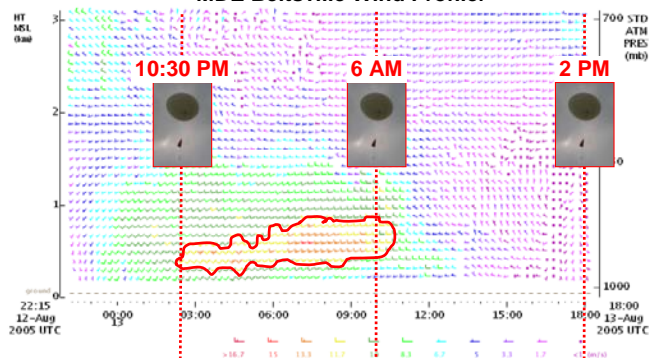


### Ozonesonde (Data Interval - 1 Sec.)

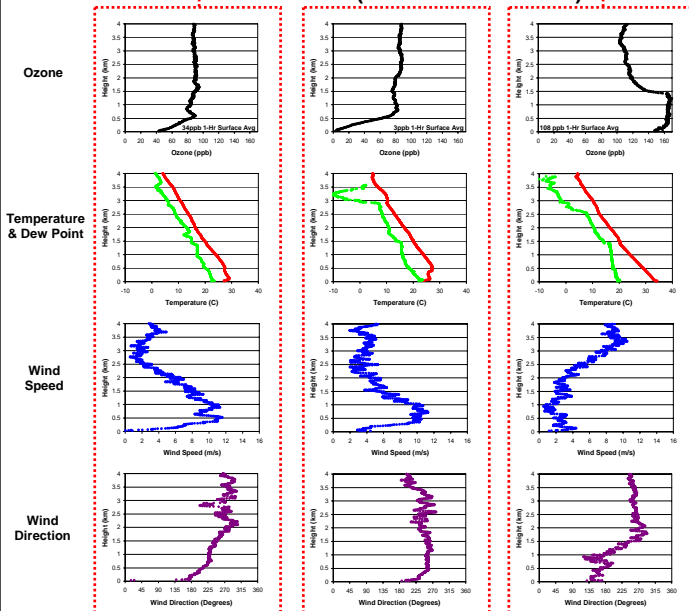


# Transport Mechanisms in a High Ozone Case - August 12-13, 2005

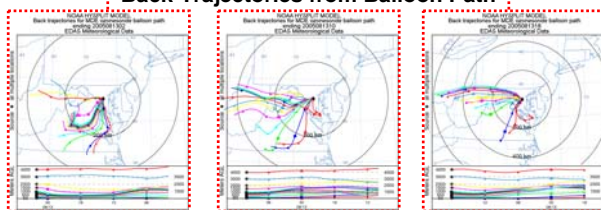
## MDE Beltsville Wind Profiler



## Ozonesonde (Data Interval - 1 Sec.)

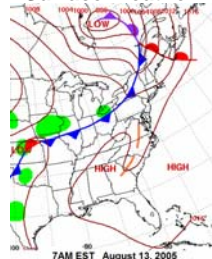


## Back-Trajectories from Balloon Path

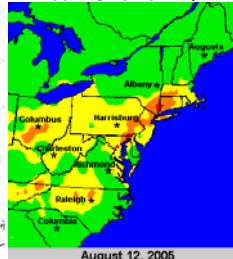


On August 13, 2005 a classic high ozone case evolved with an entrenched Bermuda High, an Appalachian Lee-Side Trough, and local stagnation. The emissions contributions occurred via synoptic-scale westerly transport, regional-scale nocturnal low level jet (LLJ), and local-scale emissions. The transport mechanisms were all in place for a tremendous ozone episode. Fortunately, the previous (August 12) day's upwind ozone AQI readings were only moderate.

## Surface Weather



## Peak Ozone AQI



Three balloon launches captured the case:

**10:30 PM** – Slow surface winds veer to a peak speed of 12 m/s that coincides with an ozone local maxima of 90 ppb where a nocturnal inversion is beginning to setup at 0.6 km. Near the inversion wind speeds reveal the early formation of a LLJ, with slower westerly winds aloft. Balloon path back trajectories show consistent SW winds.

**6 AM** – The nocturnal inversion is now more pronounced and the ozone profile shows minor increases in ozone within the LLJ. The profiler confirms the LLJ from the WSW remains strong; however the back-trajectories now show the onset of a westerly contribution.

**2 PM** – The afternoon atmosphere is less stable and well mixed. Winds are light as ozone concentrations build. Ozone concentrations reach a maximum of 170 ppb at 1.4km. The surface peak 8-hr AQI at Beltsville was 109 - Code Orange. Peak 1-hr ozone was 108 ppb.